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Analyzing Working Memory in Relation to Learning Disabilities, Age and Socioeconomic Status

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Abstract: *Present study aimed to examine the role of learning disabilities, age and socioeconomic status in the development of working memory. A total of 240 participants, age ranged 8-16 years, grade 3rd to 11th standard, from Gorakhpur district participated in the study. Raven's Standard Progressive Matrices (SPM) and Diagnostic Test of Learning Disability (DTLD) were applied to identify the learning disability in participants. Further, a set of three working memory tasks was used to assess three components of Working Memory i.e. phonological loop, Visuo-Spatial Sketch-Pad and Central Executive. Data analysis was done using correlation analysis and stepwise multiple regression analysis.*

Results report interesting facts. It was found that learning disabilities, age and socioeconomic status of participants played significant role in the development of working memory. More specifically, learning disabilities (LD) were found negatively correlated with working memory and its components. However, the capacity of working memory increases with growing age and also with increasing socioeconomic status of participants. Further, regression results revealed that types of learning disabilities and LD as a whole have proved their negative contributions to the development of working memory. Contrary to this, age and SES contributed positively to the development of working memory. Findings are discussed.

Key Words: *Learning Disabilities, Age, Socioeconomic Status, Working Memory.*

1. INTRODUCTION:

Learning is a process by which children acquire knowledge and skills. The acquisition of new material requires manipulation of information, interaction with long term memory, and simultaneous storage and processing of information. Individuals with learning disabilities are likely to have a deficiency in one or more cognitive processes including phonological processing, long term retrieval, attention, short term memory and working memory. *The term working memory refers to the ability to hold and manipulate information in the mind for a short period of time. It has often been described as a flexible mental workspace in which we can store important information in the course of complex mental activities.* Children with learning disability may have poor working memory capacity consequently they have low academic performance in comparison to their peers. A bunch of studies denotes that there is a close association between learning disability and working memory processes and many researchers believe that working memory deficits are the primary characteristics of learning disabilities. Therefore, working memory in relation to learning disabilities has been the central focus of research in developmental psychology.

Working memory is one of the most widely used terms in cognitive psychology. It is a cognitive system with a limited capacity that is responsible for temporarily holding information available for processing. We use working memory in many aspects of our everyday life including reading comprehension, mental arithmetic and planning a series of thought or actions. With advances in cognitive psychology, Baddeley and Hithch (1974, 1986), in their researches, developed a three component model of working memory - a modality free central executive closely resembling attention; an articulatory loop which can hold a limited amount of phonological or speech based information; and a visuo-spatial sketch-pad, which is devoted to spatial and visual coding. The central executive system acts as a supervisory system and controls the flow of information. The phonological loop stores verbal content, whereas the visuo-spatial sketch-pad is related to visuo-spatial data. Baddeley (2003) further modified his model and added a fourth component- Episodic Buffer. It interacts with the phonological loop and the visuo-spatial sketch pad, as well as long term memory.

Research suggests that the capacity of working memory is found closely related to wide range of high level cognitive abilities such as reasoning, problem solving and learning. Although, a number of researches indicate that working memory follows a developmental pattern with growing age yet, individual differences are found in the capacity

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of working memory. Several developmental studies have examined age related growth in cognitive functioning of children (Anderson et al., 2001; Mishra & Tripathi, 1980; Pandey et al., 2015). Many researchers reported that development of working memory is closely related with growing age of children (Gathercole, 1999; Pandey, Tamta & Tripathi, 2015). Studies proved that working memory starts to develop in the first year of life and continues to develop until adolescence (Conklin et al., 2007; Diamond, 2013; Gathercole et al., 2004; Reznick et al., 2004). A sizable number of studies have indicated the developmental pattern of working memory with its components. The working memory components (i.e. phonological WM, visuo-spatial WM, and central executive WM) appear to be present in children as young as 4 years of age (Hitch, 1990). Developmental studies reported that working memory capacity increases in children, reaches a peak in young adults and decreases with aging (Chiappe et al., 2000; Siegel, 1994). Whereas, other researchers suggest that working memory gradually improved from childhood to adolescence (Gathercole, 1999; Hulme et al., 1984; Nicolson, 1981; Roodenrys et al., 1993).

Apart from this, many studies indicated that variation in working memory is influenced by socio-demographic factors such as; socioeconomic status (Hackman et al., 2010; Merikangas et al., 2010; Pandey & Tripathi, 2019), gender (Lewine et al., 2001; Pandey, Tamta & Tripathi, 2015; Vountela et al., 2003) as well as cognitive variables i.e. reasoning ability (De Jong et al., 1995), language acquisition (Gathercole & Baddeley, 1989, 1990) and verbal ability (Pandey & Tamta, 2013; Pandey, Tamta & Tripathi, 2015). In addition, many studies in the field of neuroscience and psychology reported the prevalent effect of socioeconomic status (SES) on executive functioning of children (Hckman et al., 2010; Mackey et al., 2015; Pandey & Tripathi, 2019; Sarsour et al., 2011). Studies indicated that family's socioeconomic status (SES), especially during early childhood; seem to affect performance in some neuropsychological systems more than in others, particularly memory (episodic, working and semantic), oral and written language and executive functions (Hackman et al., 2010). In the first year of childhood, the socioeconomic status is very important for development, since it may limit the conditions for stimulation, accesses to materials and activities that favor cognitive development (Forns et al., 2012).

Out of several cognitive processes working memory has been found to be strongly related to learning disability. Individuals with learning disabilities are likely to have a deficiency in one or more cognitive processes including phonological processing, long term retrieval, attention, short term memory and working memory (Masoura, MacGinitie, Karnons, Kowalski, MacGinitie & MacKay, 2006). Children with learning disability may have poor working memory capacity consequently they have low academic performance in comparison to their peers. Several studies have reported a strong relationship between working memory, performance, reading skills (Swanson & Jerman, 2007), written expression (Kellogg, Olive & Piolat, 2007), and performance in mathematics (Hutton & Towse, 2001). Studies have indicated that children with reading disability (dyslexia) have deficit in ''phonological awareness'' which is dependent on phonological loop capacity of working memory. Generally, developing children's scores on working memory tasks are used to predict reading achievement (Swanson & Beebe-Frankenberger, 2004). Further support for the role of reading disabilities in working memory capacity comes from several studies that have found a deficiency in working memory capacity to be one of the variables that differentiates between normal and dyslexic readers (Swanson et al., 1990). Researchers believe that children with dyslexia have deficiencies in verbal working memory (Pickering & Gathercole, 2004), phonological processing (Maehler & Schuchardt, 2009), central executive functioning (Landerl et al., 2004), and visuo-Spatial working memory (Kibby et al., 2004). In a bunch of studies, it was found that low working memory scores are closely related to poor performance and arithmetic word problems (Alloway & Passolunghi, 2011; Swanson & Sachse-Lee, 2001) and poor computational skills (Bull & Scerif, 2001; Geary, Hoard, & Hamson, 1999).
A close perusal of review of above studies denotes that there is a close association among working memory, learning disability and many other factors. Therefore, this study seeks to enrich the understanding of development of working memory in relation to learning disabilities, age and socioeconomic status.

2. OBJECTIVES: Present study was carried out with following objectives:

- To examine the relationships among learning disabilities, working memory, age and socioeconomic status.
- To find out the predicting roles of learning disabilities, age and socioeconomic status in working memory and its components.

2.1 HYPOTHESES: On the basis of the above objectives, following hypotheses were formulated:

- Learning disabilities would be found negatively associated with working memory and its components.
- A developmental pattern in working memory would be found with increasing age. Specifically, age would be found positively associated with working memory and its components.
- A close link between socioeconomic status and working memory would be found.
- Learning disabilities, age, and socioeconomic status (SES), would be found strong predictors of working memory and its components.

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3. METHOD:

3.1 DESIGN: Present study is correlational in nature. Therefore, to determine the relationships and contributing roles of learning disabilities, age and SES, correlation and regression analyses were done.

3.2 PARTICIPANTS: A total of 240 participants, age ranged 8-16 years, grade 3rd to 11th standard, were selected for the present study by using purposive sampling technique. With the help of Diagnostic Test of Learning Disability (DTLD) the learning disabled (LD) and non learning disabled (Non-LD) groups of participants were diagnosed. Further, LD and Non-LD groups were matched on the basis of age, grade and family's socioeconomic status.

3.3 MATERIALS

1) **Socioeconomic Status Scale:** This scale was developed and standardized by Pandey and Tripathi (2016) to determine the participant's social and economic conditions. This scale contains 10 items related to education level, occupation and income of the family. The scoring was done following 5, 4, 3, 2 and 1 order and total summated scores indicated level of socioeconomic status of participants.
2) **Raven's Standard Progressive Matrices (SPM):** Raven's Standard Progressive Matrices (Raven, Court & Raven, 1958) were used for assessment of abstract reasoning and intelligence level of participants. The test was used to identify a pure group of learning disabled children excluding those with the below average intelligence.
3) **Diagnostic Test of Learning Disability (DTLD):** In order to identify the cases of learning disability the DTLD developed by Swarup and Mehta (1991) was used. The test consists of 100 items which diagnoses learning disability in ten areas ranging from Auditory/Visual Perception to cognitive areas, such as; Eye-hand Co-ordination (EHC), Figure Ground Perception (FG), Figure Constancy (FC), Position-in-Space (PS), Spatial Relations (SR), Auditory Perception (AP), Memory (M), Cognitive Abilities (CA), Receptive Language (RL), and Expressive Language (EL).
4) **Working Memory Task:** To assess the level of working memory in different age groups of respondents, three types of working memory tasks devised by Pandey and Tamta (2010) was used.

   a) **Reading Span Task (RSPAN):** This task was devised to measure the combined processing and storage capacity of working memory during reading. This contained 30 sentences written on a separate card.

   b) **Visual Pattern Recall Task (VSPAN):** Visual Pattern Task consisted of 25 geometric designs composed of filled (black) and unfilled (white) parts. The participants were instructed to look carefully at the pattern and try to remember where the filled parts were. The participants were asked to correctly recall the pattern by putting (✓) mark at the same part.

   c) **Operation Span Task (OSPAN):** Operation Span Task consisted of 30 items and each item was written on a separate card. Each card contains one math equation and one unrelated word. These cards were categorized under five sets based on increasing the number of items, e.g. 1st set of task includes two cards and 2nd set of task contains four cards and so on.

3.4 PROCEDURE: Present research was conducted in two phases. Firstly, participants were contacted individually at school setting and they were introduced about objective of the study. After receiving the initial willingness, they were given a booklet containing, Personal Data Sheet (PDS) and Socioeconomic Status (SES) scale for the background information. Then, Standard Progressive Matrices (SPM) was given to the participants for the assessment of abstract reasoning and intelligence level of participants. On the basis of SPM assessment, participants who scored I.Q. (Intelligence Quotient) below 90 were excluded from the study. Then, to identify the level of learning disability (LD) of remaining students, Diagnostic Test of Learning Disability (DTLD) was administered individually. On the basis of DTLD scores they were divided into LD and Non-LD groups. In the second phase of the study, the working memory task containing three types of measures viz. RSPAN, VSPAN, and OSPAN (as described earlier) was administered on participants individually and instructions were given for each task. They were requested to respond carefully. As soon as they completed these tasks, data were collected and they were thanked for cooperation. Data were scored and subjected to computer analysis.

4. RESULTS:

In order to obtain insight into the relationships among studied variables correlational analysis was done and to determine the relative contribution of learning disabilities, age and SES to criterion variables stepwise multiple regression analysis (SMRA) was also done. Results are displayed in tables and figures and reported separately for each domain of working memory and working memory as a whole.

Correlation Analysis: Correlations were computed among learning disabilities, age, SES and working memory and its components. Obtained results are displayed in table-1 and reported in the following section:

Table-1: Relationships between Learning Disabilities, Age, SES and Working Memory

Variables	Phonological Working Memory	Visuo-Spatial Working Memory	Central Executive Working Memory	Overall Working Memory
Learning Disability (as a whole)	-.772**	-.795**	-.822**	-.850**
Reading Disability (Dyslexia)	-.771**	-.733**	-.805**	-.824**
Writing Disability (Dysgraphia)	-.859**	-.822**	-.884**	-.915**
Mathematical Disability (Dyscalculia)	-.764**	-.772**	-.794**	-.830**
Age	.299**	.254**	.365**	.330**
Socioeconomic Status	.617**	.579**	.636**	.654**

N=240, **P<.01

I. Relationship between Learning Disabilities (as a whole) and Working Memory: Correlations were computed between learning disabilities (LDs) and working memory (presented in Table-1). Results indicate that learning disability as a whole was found negatively correlated with working memory and its components. More specifically, learning disability (LD) as a whole was found negatively correlated with phonological working memory (r = -.772, P<.01), visuo-spatial working memory (r = -.795, P<.01), central executive working memory (r = -.822, P<.01) and overall working memory (r = -.850, P<.01).

II. Relationship between Forms of Learning Disabilities and Working Memory: Moreover, correlations were computed between components of learning disabilities and working memory. Results evinced negative relationship between various types of learning disabilities and working memory.

i. Reading Disability: As results indicate that reading disability was found negatively correlated with phonological working memory (r = -.771, P<.01), visuo-spatial working memory (r = -.733, P<.01), central executive working memory (r = -.805, P<.01) and overall working memory (r = -.824, P<.01).

ii. Writing Disability: Again, correlation results indicate negative association between writing disability and working memory. Specifically, writing disability was found negatively correlated with each components of working memory i.e. phonological working memory (r = -.859, P<.01), visuo-spatial working memory (r = -.822, P<.01), central executive working memory (r = -.884, P<.01) and overall working memory (r = -.915, P<.01).

iii. Mathematical Disability: Further, results indicate that mathematical disability was also found inversely correlated with working memory. As Table-1 denotes that mathematical disability was identified negatively correlated with phonological working memory (r = -.764, P<.01), visuo-spatial working memory (r = -.772, P<.01), central executive working memory (r = -.794, P<.01) and overall working memory (r = -.830, P<.01).

iv. Relationship between Age and Working Memory: As Table-1 indicates, age was found positively correlated with working memory and its components. More specifically, a component of working memory i.e. phonological working memory was found positively related with age (r .299, P<.01), visuo-spatial working memory (r =.254, P<.01), central executive working memory (r =.365, P<.01), and overall working memory (r =.330, P<.01).

v. Relationship between Socioeconomic Status (SES) and Working Memory: Correlation results (Table-1) indicate that socioeconomic status (SES) was found positively correlated with each components of working memory and overall WM. More specifically, socioeconomic status of participants was found positively correlated with phonological working memory (r=.617, P<.01), visuo-spatial working memory (r=.579, P<.01), central executive working memory (r =.654, P<.01), and overall working memory (r =.654, P<.01). Thus, results suggest that with increasing level of SES, working memory capacity also increased.

Stepwise Multiple Regression Analysis (SMRA)-Significant correlation results provided base to go for stepwise multiple regression analysis. Therefore, to determine the relative contribution of LD, age and SES to criterion variables (working memory) stepwise multiple regression analysis was done. Results are presented below:

I. Prediction of Overall Working Memory: To establish the role of learning disabilities, age and socioeconomic status (SES) in overall working memory (WM), step-wise multiple regression analysis was calculated. Findings are displayed in Table-2 and Figure-1.

Table-2: Stepwise Multiple Regression Analysis of Overall Working Memory on to the Learning Disabilities, Age and SES

Predictors ↓	Criterion Variable (Overall Working Memory)				
	R	R^2	R^2 Change	Beta β	F value
Writing Disability (Dysgraphia)	**.915**	**.837**	**.837**	**-.915**	**1222.723****
Learning Disability (as a whole)	**.924**	**.853**	**.016**	**-.249**	**689.927****
Reading Disability (Dyslexia)	**.928**	**.860**	**.007**	**-.156**	**484.962****
Age	**.932**	**.869**	**.003**	**.065**	**309.152****
SES	**.930**	**.865**	**.005**	**.090**	**376.532****

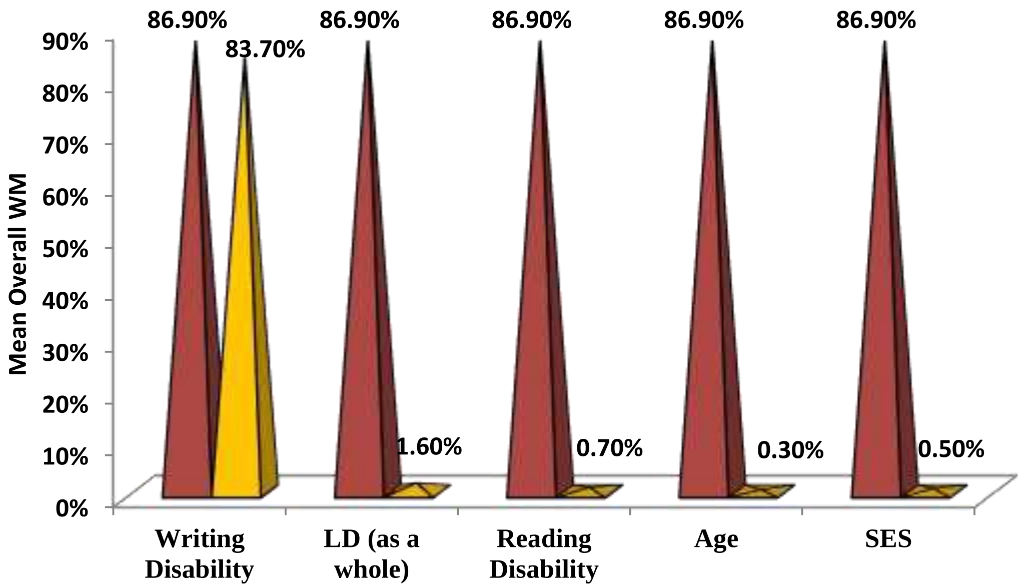

Fig. 1 Prediction of overall WM by LD, age and SES

As regression results present working memory was negatively predicted by three factors i.e. writing disability, learning disability (as a whole) and reading disability whereas, it was positively explained by SES and age. Specifically, it is clear from regression analysis overall working memory was predicted by writing disability maximum negatively (β= -.915, R^2=.837), LD (as a whole) also contributed negatively (β= -.249, R^2=.853) followed by reading disability (β= -.156, R^2=.860) which also contributed negatively. However overall working memory was positively predicted by SES (β= -.090, R^2=.865) and age (β= -.065, R^2=.869). Though independently, writing disability has contributed 83.7% variance, LD (as a whole) has contributed 1.6% variance, reading disability has contributed 0.7% variance. Further, SES explained 0.03% variance in criterion variable. But the composite contribution of these factors was found 86.9% variance in the overall working memory (Table-2 and Fig-1).

II. Prediction of Components of Working Memory:

Moreover, to determine the role of learning disabilities, age and socioeconomic status (SES) in various types of working memory step-wise multiple regression analysis was done. Findings are reported in the following section.

a) Prediction of Phonological Working Memory: It is clear from Table-3 and Figure-2 that phonological working memory was negatively predicted by writing disability (dysgraphia) and reading disability (dyslexia) but positively predicted by socioeconomic status of participants.

Table-3 Stepwise Multiple Regression Analysis of Phonological Working Memory on to the Learning Disabilities, and Socioeconomic Status

Predictors ↓	Criterion Variable (Phonological Working Memory)					
	R	R^2	R^2 Change	Beta β	t-value	F value
Writing Disability (Dysgraphia)	.859	.737	.737	-.859	-25.850	668.234**
Socioeconomic Status	.864	.747	.010	.127	3.031	350.207**
Reading Disability (Dyslexia)	.867	.752	.005	-.132	-2.144	238.544**

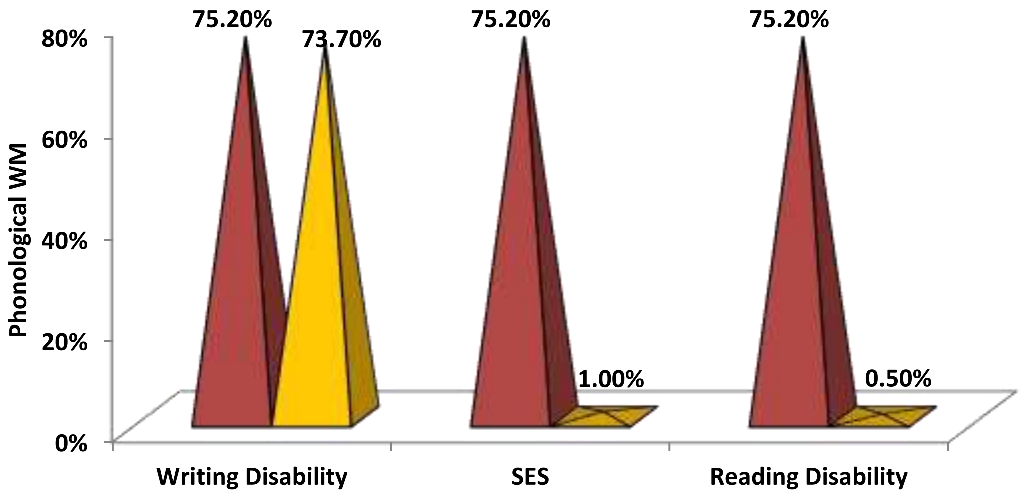

Fig. 2 Prediction of Phonological Working Memory by Learning Disabilities and SES

More specifically, Writing disability was found the strongest predictor of phonological working memory, which contributed maximum negatively (β = -.859, R^2 = .737) whereas, SES explained positively (β= .127, R^2 =.747). Again, phonological working memory was negatively predicted by reading disability (β= -.132, R^2 =.752). Though independently, writing disability contributed 73.7% of variance, SES contributed 1% of variance and reading disability explained 0.5% of variance but the composite contribution of all the factors was found 75.2% of variance in phonological working memory.

b) Prediction of Visuo-Spatial Working Memory

Table-4 Stepwise Multiple Regression Analysis of Visuo-Spatial Working Memory on to the Learning Disabilities, Age and SES

Predictors	Criterion Variable (Visuo-Spatial WM)					
	R	R^2	R^2 Change	Beta β	t-value	F value
Writing Disability (Dysgraphia)	.822	.676	.676	-.822	-22.285	496.632**
Learning Disability (as a whole)	.841	.707	.031	-.341	-4.987	285.656**
Mathematical Disability (Dyscalculia)	.845	.714	.007	-.167	-2.362	195.978**

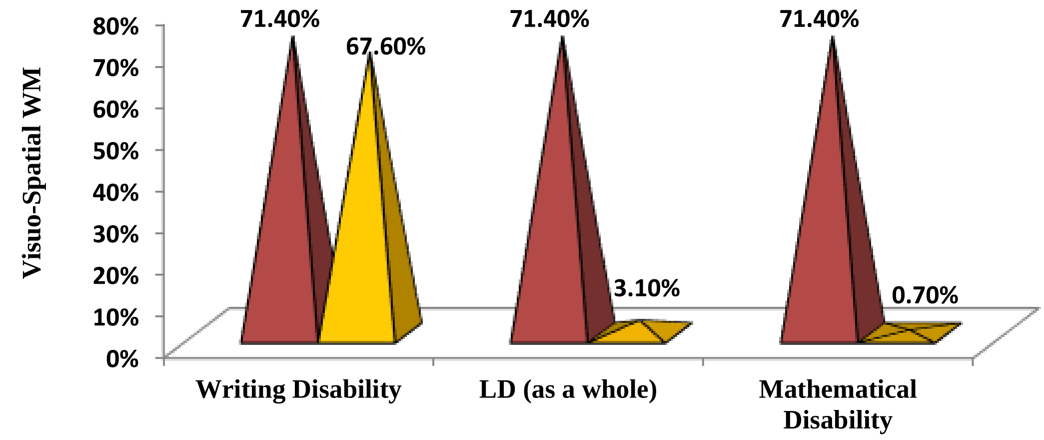

Fig. 3 Prediction of Visuo- Spatial Working Memory by Learning Disabilities

It is clear from the Table-4 and Figure-3 that writing disability was found the strongest negative predictors of visuo-spatial working memory, which has contributed maximum negatively (β= -.822, R^2= .676), followed by learning disability (as a whole) (β=-.341, R^2=.707) and mathematical disability (β=-.167, R^2=.714). Though independently, writing disability explained 67.6% variance, learning disability as a whole has contributed 3.1% variance and mathematical disability explained 0.7% variance but the composite contribution of these factors was found 71.4% variance in criterion variable.

c) Prediction of Central Executive Working Memory

Table-5: Stepwise Multiple Regression Analysis of Central Executive Working Memory on to the SES, Age and Learning Disabilities

Predictors ↓	Criterion Variable (Central Executive WM)					
	R	R^2	R^2 Change	Beta β	t-value	F value
Writing Disability (Dysgraphia)	.884	.782	.782	-.884	-29.245	855.29**
Learning Disability (as a whole)	.893	.798	.015	-.240	-4.226	466.86**
Reading Disability (Dyslexia)	.898	.807	.009	-.181	-3.383	328.77**
Age	.903	.816	.009	.102	3.391	260.42**
SES	.907	.823	.007	.115	3.104	217.920**

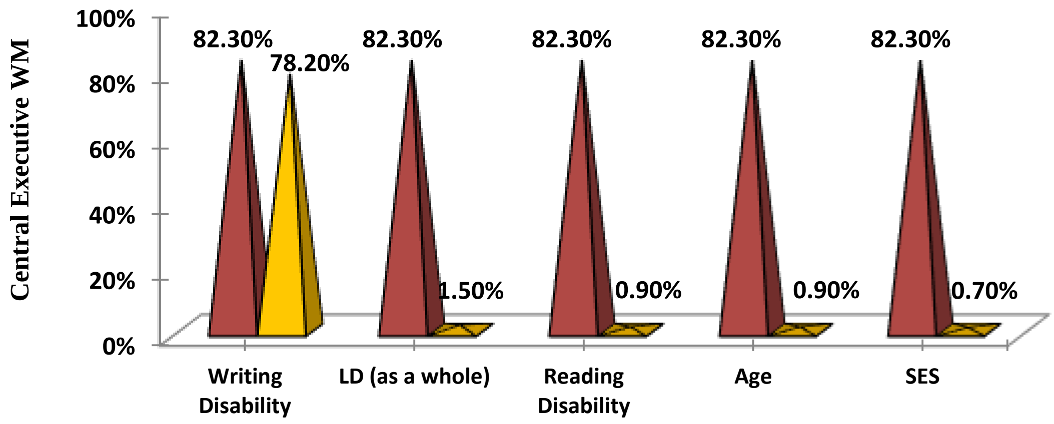

Fig. 4 Prediction of Central Executive Working Memory by Learning Disabilities, Age and SES

Table-5 and Figure-4 show that writing disability was found the strongest predictor of central executive working memory, which contributed maximum negatively (β= -.884 R^2= .782) followed by learning disability as a whole (β=-.240 R^2= .015) and followed by another factor i.e. reading disability (β=-.181 R^2= .807), Whereas, Central executive WM was positively predicted by Age (β=-.102 R^2= .816) and SES of participants (β=-.115 R^2= .823). Though independently, writing disability has contributed 78.2% variance, learning disability (as a whole) has contributed 1.5% variance, and reading disability has contributed 0.9% variance. Further, age contributed 0.9% variance and SES has contributed 0.7% variance. But the composite contribution of all the factors was found 82.3% variance in central executive working memory.

Thus, an overview of regression results evinced that learning disabilities exhibited adverse impact on the development of working memory whereas, age and socioeconomic status of participants contributed positively to the development of working memory and its components. Results have been interpreted and discussed in the following section.

5. DISCUSSION:

This study investigated working memory in relation to learning disabilities, age and SES. Findings of present study proved that learning disabilities have caused detrimental impact on the proper development of working memory. Moreover, different types of learning disabilities and LD as a whole were found inversely correlated with working memory whereas; SES and age were found positively linked with working memory and its components. In other words, capacity of working memory increased with increasing age and level of SES whereas, learning disability diminished the proper development of working memory. Apart from this, various types of learning disabilities, age and socioeconomic status were found strong predictors of working memory and its components.

More specifically, regression results reflected that different types of learning disabilities contributed negatively to the development of working memory. Phonological working memory was negatively predicted by writing disability and reading disability. Again visuo-spatial working memory was negatively predicted by writing disability and mathematical disability. Furthermore, central executive working memory was negatively explained by writing disability, reading disability and LD as a whole. Similarly overall working memory was negatively predicted by writing disability, reading disability and LD as a whole. In brief, regression results revealed that types of learning disabilities and LD as a whole have proved their negative contributing role in the development of working memory. Contrary to this, age and SES contributed positively to different components of working memory and overall WM. Specifically, central executive WM and overall WM were positively predicted by age whereas, phonological WM, central executive WM and overall WM were positively predicted by socioeconomic status. Results are also supported by other empirical and theoretical interpretations.

This study examined the role of learning disabilities in working memory. Results evinced that learning disability and its various forms predicted negatively to working memory and its components. A number of studies have reported strong association between working memory and learning disabilities. Gathercole and Pickering (2001) compared the working memory profile of 10 children who were identified as having learning disability with 42 Non-LD children. Results showed that the LD group performed significantly poorer than the Non-LD group. Researchers believe that children with reading disability have deficiencies in verbal working memory (Pickering & Gathercole, 2004), phonological processing (Maehler & Schuchardt, 2016), central executive functioning (Landerl et al., 2004) and visuo-spatial working memory (Kibby et al., 2004). Number of studies suggested that writing disabled students have been found impaired on phonological awareness (Moll et al., 2009) and phonological working memory (Steinbrink & Klatte, 2008; Steinbrink et al., 2008). In a recent study, Dohla, Willmes and Heim (2018) have found the writing disabled students exhibited deficits in visuo-spatial attention skill. Moreover, several scholars considered working memory impairment as a central deficit in children with mathematical disabilities (Geary, 1993; Passolunghi et al., 1999; Passolunghi & Siegel, 2001). Swanson and Sachse-Lee (2001) highlighted that children with mathematical disability showed an impaired performance in phonological processing, phonemic deletion and digit span forward. Researches revealed that phonological working memory is a reliable indicator of mathematical disabilities in the first year of formal schooling (Bull & Scerif, 2001; Gersten, Jordan & Flojo, 2005) but not in older children (Reuhkala, 2001). In Indian context, researchers have examined consequences of learning disabilities on the proper development of working memory. They identified that LD children showed poor working memory as compared to Non-LD children (Pandey & Tripathi, 2019). Earlier, Pandey and Tamta (2013) examined working memory in abused children. They found that abusive experiences of children caused detrimental impact on proper development of working memory.

Another important finding of this study is that age exercised positive influence on working memory and its components. More specifically, adolescents were found far superior on phonological WM, visuo-spatial WM, central executive WM and overall WM as compared to pre-adolescents and children respectively. In a study Gathercole et al. (2004) reported that children's working memory span increases steadily between 3-15 years of age. Humle et al. (1984) studied the digit span and other serial recall spans in group of children aged 4, 7 and 10 years and reported an average

2-3 fold increase in span between 2 and 3 items at the age of 4 years to about 6 items at the age of 12 years. In Indian context Pandey et al., (2015) explored a gradual developmental trend in working memory with growing age. Several studies also showed developmental changes in working memory, due to many factors like; brain maturation, increases in the processing speed of information (Kail et al., 1994), increase in knowledge (Roodenrys et al., 1993), better use of strategies (Flavell et al., 1996) and more effective management of attention. In a series of studies, it was found that 3-5 years of children's immediate recall was sensitive to phonological similarity and word length (Ford & Silber, 1994; Gathercole & Adams, 1993; Hitch & Halliday, 1983; Hulme et al., 1984). previously Wilson et al. (1987) showed that visual memory span increases substantially and regularly between 5 and 11 years. Similar patterns of development of visual patterns were also obtained by Miles, Morgan, and Morris (1996). Thus, studies on development of working memory reported that capacity of each component of working memory gradually increased with growing age.

The findings of the present study are consistent with those from other studies that have demonstrated the contribution of SES on cognitive performance at different age ranges (Blair et al., 2011; Lupien et al., 2001; Noble et al., 2006, 2007; Piccolo et al., 2012). Numerous researches have demonstrated that low SES has a direct negative influence on development of cognitive abilities of children (Hackman & Farah, 2009; Mackey et al., 2015; Noble et al., 2015). Number of studies identified SES disparities in the tasks of goal-setting, cognitive flexibility, and working memory in 3-5 years old children (Lipina et al., 2004) and in measures of alerting and executive attention in 4-7 years old children (Mezzacappa, 2004). As suggested by Forns et al. (2012), SES plays a very important role in the cognitive development of early childhood because low SES of parents may limit the conditions for stimulation, access to materials and activities that favours in cognitive development. Brooks-Gunn and Duncan (1997) found that childhood poverty influences a broad diversity of child outcomes, which can be classified into poor executive functioning, poor school achievement and deficits in emotional and behavioural domains. Evidence suggests that early SES related differences in executive function persist throughout childhood (Ardila, Rosselli, Matute & Guajardo, 2005). Further, findings have demonstrated that childhood SES conditions affect the later cognitive functions of adults (Evans & Schamberg, 2009; Guralnik, Butterworth, Wordsworth & Kuh, 2006; Kaplan et al., 2001). Pandey and Tripathi (2019), explored that working memory capacity was found far superior in high SES children as compared to middle and low SES children.

Present study thus proved that in addition to learning disability, age and SES also played important roles in the development of working memory. Findings have been supported by a number of empirical and theoretical evidences.

6. CONCLUSION:

Present research proved the effects of learning disabilities, age and socioeconomic status on working memory. Both correlation and stepwise multiple regression analyses were exercised. An overview of the findings of the present study confirmed the hypotheses that due to learning disability (LD) students displayed lower level of working memory. Specifically, learning disability and its various types have proved their negative contributing role in the development of working memory. Therefore, learning disabilities were identified as significant barrier in the development of working memory. Despite this, the important contribution of age and socioeconomic status (SES) were also found in the development of working memory. Specifically, development trend was identified in working memory and its components. Further, findings clearly evinced that students with high SES were found superior on each components of working memory and overall WM than middle and low SES group. Thus, the study proved that learning disability as well as age and SES played pervasive role in the development of working memory.

Present study provides valuable data, which emphasize on some unexplored areas of empirical investigation of working memory and learning disabilities. Yet there are few limitations of this study. First, generalization of the results from this study is limited as the sample size is small and limited to Gorakhpur, one region of Uttar Pradesh. Secondly, working memory functioning and its deficits should be explored more specifically in subtypes of learning disability.

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